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Considering the history of digital technologies in education

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Abstract
Over the past century, numerous key technologies (including digital technologies) have been introduced into education. For the most part, each of them has been expected to revolutionise teaching and learning. However, it is generally accepted that neither dramatic reorientations nor changes in education have happened. Yet, while use of technology over the last 100 years has not resulted in a revolution, several key improvements and advancements in educational access and equity have resulted. The critical focus of this chapter is to look beyond the hype of technology and media over the last century and, instead, critically consider the significance of the changes over time in terms of how we understand teaching and learning with technology today. To explore this issue, the chapter examines what we have labelled as three 'ages' of technology integration: pre-digital, personal computer and the internet. While these three ages are described, it would be a mistake to assume that this is the only interpretation of a history of technologies in education. Depending on your geographic location, socioeconomic situation, cultural background, literacy and other variables, the history you and your family and community experience is different. For example, internet connectivity and the ensuing changes to education opportunities was available in metropolitan areas years prior to rural communities, and even today is problematic in remote areas. This chapter presents one interpretation by looking at three significant changes in technology provision in education. The technologies of each age were not adopted in education as expected, but they presented a range of benefits. These expectations and benefits will be discussed in relation to some key influencing social trends and beliefs about learning of the time. The chapter concludes by considering how a critical view of digital technologies over time informs our understanding of teaching and learning.

Keywords
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Introduction

Over the past century, there have been numerous key technologies (including digital technologies) introduced into education. For the most part, each of these technologies has been expected to revolutionize teaching and learning. However, it is generally accepted that dramatic reorientations or changes in education have not happened. Yet, while use of technology over the last 100 years has not resulted in a revolution, several key improvements and advancements in educational access and equity have resulted. The critical focus of this chapter is to look beyond the hype of technology and media over the last century, and instead critically consider the significance of the changes over time in terms of how we understand teaching and learning with technology today.

To explore this issue, the chapter examines what we have labelled as three 'ages' of technology integration: pre-digital, personal computer and the internet. While we describe these three ages, it would be a mistake to assume that this is the only interpretation of a history of technologies in education. Depending on your geographic location, socio-economic situation, cultural background, literacy and other variables, the history you and your family and community experience is different. For example, internet connectivity and the ensuing changes to education opportunities was available in metropolitan areas years prior to rural communities, and even today is problematic in remote areas. This chapter presents one interpretation by looking at three significant changes in technology provision in education. The technologies of each age were not adopted in education as expected, but they presented a range of benefits. These expectations and benefits will be discussed in relation to some key influencing social trends and beliefs about learning of the time. The chapter concludes by considering how a critical view of digital technologies over time informs our understanding of teaching and learning.

Critical questions

- Why is there such a large emphasis on technology integration in education?
- Why has technology integration not happened in the way expected?
- Has the push for technology integration led to improved education?

Pre-digital: Film, radio & television (1890s to 1970s)

The history of educational technology is a well-trodden topic, with the mixed results of technology integration in teaching and learning well documented. It is important to have knowledge of the history of educational technology, so you can better understand expectations of technology integration, and make informed decisions about using technology, in your own practice. When discussing technology in education we could refer to the simple pen, or even chalk. However, for this chapter we will begin the discussion with film, radio and television. While these are pre-digital technologies they are important precursors to how recent technological innovations are viewed socially and in education.

Film and radio were introduced into schools in the late 1890s and 1920s, respectively. Television was introduced in the 1950s. They were slower to be adopted in rural, regional and remote areas. Importantly, these technologies were commonly available in households and not specifically designed for education. Larry Cuban (1986) provides an important analysis of film, radio and television use in teaching, in his book *Teachers and machines: The classroom use of technology since 1920*. In this analysis, he considers use of these technologies from

1900 to the 1980s. All three were introduced with considerable excitement about the learning and teaching possibilities. It was thought that each would open up the classroom to the rest of the world and revolutionize education. Yet, despite this hype all three were used in a limited way in teaching and learning. This difference between expectations of technology use and actual use was a result of tensions between educational policy and popular opinion, and realities of the classroom, teaching and learning.

Influences

In the early 20th century, expanding the classroom and educating more children became a national and economic priority in many countries. Governments began to publicly fund education, which resulted in rapid increases of students in secondary schools (Cuban, 1986). At the same time, ideas of efficiency and productivity were rapidly spreading with industrialisation. Therefore, teaching strategies and technologies that could efficiently reach large numbers of students in a direct and efficient manner were desired. Film, radio and television suited this social aim.

All three technologies 'delivered knowledge' to students, through visual and audio channels. It was thought that they could easily be integrated with existing traditional textbooks and written tasks. The combination of media, particularly in television, was thought to be 'the closest thing to real experiences' (King 1954, p. 20, cited in Selwyn, 2011) and an efficient mechanism through which the classroom could be expanded (1954, p. 373). This was the beginning of the use of visual aids and visualization of instruction. The popular view of these technologies and their benefit was so positive that some believed students could learn everything they needed to know through viewing films and television or listening to radio broadcast programming (Selwyn, 2011).

This suited the popular view of learning at the time. In the early 1900s, learning was understood through behaviourist theories (Goodman, 1995). This group of theories proposed that environment shaped behaviour and learning. Children were seen as 'empty vessels' that had to be filled with knowledge, such as the alphabet, state capitals and times tables. Children could be conditioned to do certain things and the evidence of this was learning. This was mostly done through teacher lectures, repetition, drills and practice, which are often referred to as 'teacher-centred' practices. This approach to learning was commonly referred to as *objectivism*. At the time, lesson and curriculum design were not explicitly objectivist, they often manifested these principles. In this approach, lessons were based on identifying, providing resources to support, and measuring learning *objectives* (Goodman, 1995).

Implications

The expected revolutions did not occur. For all three technologies, relatively low adoption was seen in schools. The tools were expensive, logistically difficult to set up and organize in the classroom, and teachers did not feel confident using them. More importantly, while educational materials were created for use with these technologies, much of the popularly available content was not relevant in education. Research was also showing that learning was not significantly improved with use of these tools (Cuban, 1986). However, while learning was not significantly different from existing approaches, the use of film, radio and television did provide a *wider range* of resources that could be used and reused in learning. For example, where previously students may have only read about volcano eruptions, film and/or television provided a way for them to watch an eruption. This may not have been a 'real

experience', but these media offered richer access to phenomena, travel and knowledge previously accessible only through text descriptions or not available in the classroom at all.

Another important change resulting from radio was in distance education. In Australia, previously children who were unable to attend a regular school learned via correspondence texts, which provided no interaction and students often fell behind in their studies. Two-way radios were made available through the School of the Air program, starting in 1951 (Powerhouse, n/d), for children living in remote regions. Using the two-way radio students were able to talk to a teacher or to other students. This was a significant change in how students experienced learning and the quality of their learning.

The important message of this age and the use of film, radio and television is that there were great expectations for use of these tools in education, but they were not realized. Educational technologists, government and the public thought a revolution in education would happen, and when it did not teachers and their schools were blamed. However, there were a number of significant limitations in teaching, learning and the classroom affecting their adoption. Further, there was no evidence that learning was improved by use of these tools. All three of these technologies demonstrate trends of difference between what is expected of educational technology and what happens in the classroom.

Digital technologies: Personal Computers (1970s)
In the 1970s and early 1980s, desktop computers became affordable enough to be purchased by schools. Similar to the pre-digital technologies, there was overwhelming and relatively unsubstantiated public belief in the positive learning benefits of computer use. Education departments began to purchase computers to have in classrooms and to equip computer labs. Computer businesses, such as Apple and IBM, also invested in education initiatives by purchasing computers for schools and developing educational software and content. Again, it was believed that computers would revolutionize education.

Selwyn's (2011) book *Education and Technology: Key Issues and Debates* discusses how 'computer-tutors' were expected to deliver skills, such as drill-and-practice, and support creative thinking and problem solving. They would provide tailored learning suited to the needs and motivations of students. Ultimately it was thought that through the use of computer-based instruction, any child or adult could be provided with flexible and individualized education (Suppes, 1966).

Influences
In Cuban's (2001) book *Oversold & Underused* he examines how belief in the benefits and efficiencies of computers were reflective of school reforms of the time. Reforms and change continued to be about efficiency and reaching more students, but they were also about productivity and accountability. Emphasis on learning objectives and measuring learning continued to be strong in education. Governments were investing money in computers and other technologies in schools; they wanted to see results from the funding. This increased emphasis on the measurement of learning outcomes, often through state or national standardized testing. Schooling was also influenced by the belief that skills and knowledge for the workplace were changing. There was going to be less need for unskilled manual labour and more need for workers to think and solve problems (Hutchins, 1990, as cited in Goodman, 1995). Computers and computer literacies were viewed as a key component of this

future workplace. Therefore, schools were expected to prepare students for critical thinking in this technology-rich environment.

In this environment, student access to computers in school became very important. The ratio of 'students to computers' became a benchmark and point of comparison for quality and success in schooling (Cuban, 2001). In the 1980s, this resulted in increased investment in school computer labs and computers in the classroom. Later on, one-to-one laptop programs became popular. The thinking behind these programs was that all students would have full and unlimited access to the technologies *needed* to prepare for future work, and that the laptop could be individualized to the students' needs or ways of working. The first of these programs was implemented in Australia, in the early 1990s. Since that time there have been a number of one-to-one computer initiatives internationally, one of the largest being the Australian Digital Education Revolution (2007-2014). Many of these one-to-one programs, such as the One Laptop Per Child (OLPC) initiative, believed that use of computers would support increased social equality in education and society, through making technological knowledge and skills accessible to all children.

Increasing numbers of computers in schools provided for increased individualization and new ways of learning through use of software, programming, use of computer tutors and games. It was believed that the use of computers was most appropriately understood through learning theories of cognitivism and constructivism (Jonassen, 1991), which were learning theories introduced in the early 20th century. These approaches posited that children were not 'empty vessels', but that they brought prior knowledge and experience with them and these were important components of learning. Educational technologies aligned these theories within a collective view of 'student-centred' teaching, which emphasized learning activities focused on student construction and investigation (see Papert, 1980).

It was widely believed that to fully take advantage of computers teachers needed to adopt a student-centred approach to teaching. An example of this was the Apple Classrooms of Tomorrow (ACOT; 1985) project, conducted in California (see Sandholtz, 1997). In programs such as this, it was believed that computers were a change agent that would initiate teaching reform from a teacher-centred model, where knowledge is given to students through lectures and texts, to a more student-centred paradigm, where students are supported by technology to collaborate and create their own learning. These ways of learning aligned with the idea of future work and the types of skills it was thought students would need.

Implications

Cuban (2001) identified that the use of computers resulted in no measurable change in students' test scores and no real change in learning and the same problems of the pre-digital technologies persisted. While computers over the 1980s, 90s and into the 2000s became increasingly available in schools, adoption and use in the teaching and learning continued to be relatively limited. Teachers were not confident using computers, the computers were often unreliable, they were difficult to access and negotiate with larger classes, and much of the software was not designed to suit educational aims. These limitations were easier to negotiate in the primary classroom, where teachers had more flexibility with time delays or being able to easily switch to a different activity At the secondary level, where the timetable is much tighter and there is less flexibility in the classroom, the risk of technology issues impacting on teaching time was more of a problem. The difference at this time in education was that the pressure to use technology had increased. Pre-digital technologies were not seen as essential

for future work, but computers were. The pressure on schools to ensure students were using computers was strong; teachers were blamed for the low take-up. Low and minimal computer use was seen as disadvantaging students.

Critically, a 'digital divide' became obvious between the 'have's and 'have-nots'. Schools in traditionally disadvantaged lower socio-economic areas were not able to provide students with the same level of computer access as those in more affluent areas. Therefore, emphasis on technology use actually increased the potential for disadvantaging students in these schools. Teachers in lower socio-economic schools were also more likely to face significant challenges using computers, such as less training and more complex learning environments (Cuban, 2001).

While the introduction of computers in education did not result in a revolution, like film, radio and television, the range of tools available for teaching and learning increased. Computers offered tutoring programs, games, electronic reference materials, word processing and database tools that could be integrated into teaching. Importantly, tutoring and game programs were often designed to address specific learning objectives, such as learning fractions, were easily adopted in the classroom and could be aligned with specific learning outcomes. These were adopted more quickly in the United States, as they were often aligned to US learning outcomes. Productivity tools such as image editing, word processing and presentation programs, which were designed for business uses, were more difficult to align to explicit outcomes. However, these were adopted more quickly in places like Australia, where there was less development of education specific tools.

The growing emphasis on student-centred approaches in teaching and the use of technology stimulated some teachers to think about teaching and learning differently; but, it was problematic and alienating for many others. Over time, this belief started to position teacher-centred practices as disadvantaging students, while technology integration and student-centred practices were seen as more appropriate and relevant. Some teachers reported feeling pressured to change their practice, and they were uncertain how these new strategies would meet learning objectives (Cuban, 2001). This complicated existing uncertainty and difficulties of technology use.

In response, some technology-focused professional development programs and technology tools started to look more carefully at how teachers worked, instruction and requirements of the classroom (Sandholtz et al., 1997). However, the disconnect between digital technologies and teaching and learning is not a new theme. The story of computer use continues the trend observed with film, radio and television. A revolution in education was expected, but it did not happen. With the computer the pressure for teachers to change their practice and adopt digital technologies intensified, but the issues limiting use, such as knowledge of new technology, time to develop materials and relevance to learning, were roughly the same as with older technologies.

Connected digital technologies: The Internet (1990s)

The third 'age' of educational technology examined in this chapter is that of connected digital technologies. In particular, this includes use of computers and other devices that are connected through local networks or the Internet. Again, it was believed that access to the Internet and the opportunities for learning would revolutionize and democratize education.

By the end of the 1990s, most schools had access to the Internet in some form. At this time, resources accessible through the Internet were *static*, rather providing a way for people to contribute their own content. While static, these webpages provided a platform for people to access information and knowledge from all over the world that previously was not possible. The main forms of online communication were text-based, such as forum postings, online chatting and email. Importantly, they could be hyperlinked, using URLs, which presented a new way of thinking about relations among and between information and sources. This was considered a major advancement in learning in that a limitless range of resources and information could be connected (Dillon & Gabbard, 1998). In early 2000, the internet became *dynamic*. This meant that individuals could interact online and online content could be created. Key aspects of this change were the capacity to search using natural language and the capacity to predict words (e.g. Google Search), authoring content became available to everyone (e.g. wiki sites, product reviewing) and increased social interaction (e.g. discussion boards, online groups). These types of interaction evolved to support growing popularity of social networking, video conferencing, geo-tagging and mapping, cloud computing – just to identify a few. In education, these networked technologies are thought to support sophisticated communication, sharing, curating and creation of content.

Most of these technologies had not been developed for education specifically, but have been adopted for use in learning contexts. Along with developments in how individuals are able to interact and engage on the Internet, the devices used to access these resources have also changed. Since 2007, the power and portability of smartphones and tablet computers has changed how online resources and content is accessed and experienced. There have also been two significant education-specific technology developments that have been widely adopted, the interactive whiteboard (IWB; circa 1999) and online learning management systems (LMS; circa 2000).

Influences

In parallel with rapid technological development of the computer, society was moving quickly into the Information Age (Voogt & Knezek, 2008). The development and availability of newer and more mobile digital technologies, resulting in new ways to work and communicate sped up this process. In terms of teaching and learning, these changes increased pressure on schools and teachers to integrate new digital and information skills and knowledge in students' learning. These have been so highly valued in society that they are now referred to as literacies, meaning they are thought to be necessary for basic engagement and participation in society. In Australia, the national curriculum has positioned the capability to use information and communication technologies as a general capability, along with literacy and numeracy.

These new literacies are often collectively identified as 21st century skills. While these collective skills have included the capacity to use new technologies, they have otherwise reflected traditional higher order thinking and analytic skills. The use of digital and Internet technologies in teaching and learning have been frequently positioned as being the most effective way to engage students with 21st century skills (higher order thinking skills), especially when taught through student-centred approaches, such as project and inquiry-based approaches. These teaching strategies typically pose a problem or question to students, such as scientific or historical dilemma or misconception, which must be solved or investigated using a range of online resources. The assessment could be a multi-media presentation

incorporating evidence and products demonstrating a solution to the problem, where students explain their thinking and analyse their findings.

Implications

Investment in one-to-one device programs, computer labs, high-speed internet connections and software has resulted in increased technology use in the classroom, but there has not been a *revolution* in education, teaching or learning. Evidence of gains in learning resulting from technology integration has been identified. Tamim et al.'s (2011) analysis of integration across all grade levels and higher education through a wide range of technologies identified a 12% gain in learning when using technology. However, results showed that gains were not from technology use; they were more likely from other teaching, learning and school factors.

The same issues facing teachers when using technology have persisted and become more complex. Teachers have continued to exhibit low confidence with the use of new types of technology, which has been compounded by the increasing variety of digital technologies to learn. Where increased technology use has been observed is around tools that replicate existing practices, such as use of the IWB for classroom presentations and board-focused group work, internet research tasks, drill and practice tools, use of video and online texts. However, these technology practices have been questioned in regard to how much they engage students in critical thinking or collaboration. Lack of explicit expectations for using technology in teaching and questions about 21st century skills have limited pedagogical changes associated with technology use. Many project and inquiry-based approaches to student-centred learning require extended time on the computer, a different kind of classroom format and classroom management. This pedagogical shift can be difficult for teachers to negotiate without significant school support beyond providing technologies, such as extra time to plan and experiment and support to attend both pedagogical and technological professional development.

Much of the previous discussion focuses on use of technology at the school level. It is important to note that learning management systems, similar to the radio and television, have presented significant changes in distance education. Primarily adopted in higher education and Schools of the Air, beginning around 2000, these online spaces originally included chat, discussion boards, links to documents and online resources. Ten years later, they also include streaming group video capacities, collaborative workspaces, group authoring, etc. This presented a significant development in interaction and communication for distance learners. In the last few years, these online spaces have evolved into massive open online courses (MOOCs), which are designed to include potentially thousands of students in any one online class.

However, as with the digital divide among access to computers, research has suggested that access to and use of the Internet increased inequality. Cuban (2001) addressed this key issue in *Oversold & Underused*. He explained that the quality of internet access has significantly affected the types of online resources, interactions and activities available in the classroom. Warschauer and Matuchniak (2010) in their review of *New Technology and Digital Worlds: Analyzing Evidence of Equity in Access, Use and Outcomes* have taken this further. Their research identified that teachers in lower socio-economic schools actually used technology in different and often 'less meaningful' learning tasks and less critical engagement with information. This divide in how technology or information is used, has been called the 'second digital divide'.

To conclude this section, the key point is that as digital technologies have increased in complexity, presence in society, but a revolution in education has not occurred. Importantly, greater access to online tools and digital devices in schools has resulted in increased us in teaching and learning. While there is progress in technology adoption in the classroom, many of the same issues affecting use of earlier technologies continue to limit dramatic changes in teachers' practice.

Concluding comments

The key trend in this history of educational technology is that with each new technology, a revolution is expected. With each new technology social expectations have been high, but actual classroom use has been low and/or problematic. As Cuban and Selwyn both outline, technologies have often not been designed for educational use, technologies are often unreliable and difficult to set up, and teachers have been uncertain how to best use the new tools in the classroom.

However, it is important to understand that these technologies have been adopted and widely used, but not in the timeframe or ways expected by society. This is illustrated through the evolution of film and radio in the form of videos, movies, podcasts, etc., in teaching and learning. These are now widely present in the classroom. A few of the reasons for this include the volume of appropriate media, particularly through online videos and podcasts. Further with improved broadband speeds and connectivity in schools, these resources are easy to access and reliable. This is combined with the belief that these media are an effective strategy to engage students in learning. Moreover, strategies using these media have had time to develop. Similar cases can be made for a range of digital technologies and online resources, as teachers have time to explore and share useful tools and successful practices.

Over time, as teachers became more familiar with different technologies, strategies for classroom use become accepted, relevant tools are adopted while others are passed over. Educational change relies on schools and teachers having and understanding digital technologies that are appropriate to specific learning aims and outcomes. As a teacher, you decide how these can be best used in teaching and learning to achieve those outcomes.

Exploring

Ask three teachers in your school what has influenced changes in teaching (e.g. different technologies, parent expectations, etc.) since they started in the profession, in the following areas.

1) Their planning and assessment, e.g. marking, creating lessons, etc.
2) Their teaching, e.g. use of an IWB, tablets, types of tasks and assessments.
3) Communication with colleagues, parents and students, e.g. email, social networking, etc.

What are implications of these changes (e.g. effect on learning, time, engagement, etc.)? Try to ask an early career, mid career and late career teacher.

Further reading

Cuban, L. (2001). *Oversold and underused: Computers in the classroom*. Cambridge: Harvard University Press.
A critical view of technology integration in the 1980s and 90s. This reading draws connections between government, technology industry and education agendas.

Dwyer, D. (1994). Apple classrooms of tomorrow: What we've learned. *Educational Leadership*, *51*(7), 4–10.
ACOT was one of the first longitudinal studies of computer use in the classroom and close examination of student-centred learning with technology change.

Selwyn, N. (2011). *Education and technology: Key issues and debates*. New York: Continuum International Pub. Group.
This book provides a critical view of the history of educational technology.

Websites
Innovative Learning: Educational Psychology
http://www.innovativelearning.com/teaching/behaviorism.html
This web resource will give you more information about behaviourist, cognitivist and constructivist learning theories.

The Horizon Reports
http://www.nmc.org/horizon-project
The New Media Consortium publishes reports on new digital technologies and issues about technology related change.

The School of the Air and Remote Learning
http://australia.gov.au/about-australia/australian-story/school-of-the-air
This resource will give you more information about Australia's School of the Air. This program has been able to increase access to education in remote areas of the country.

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